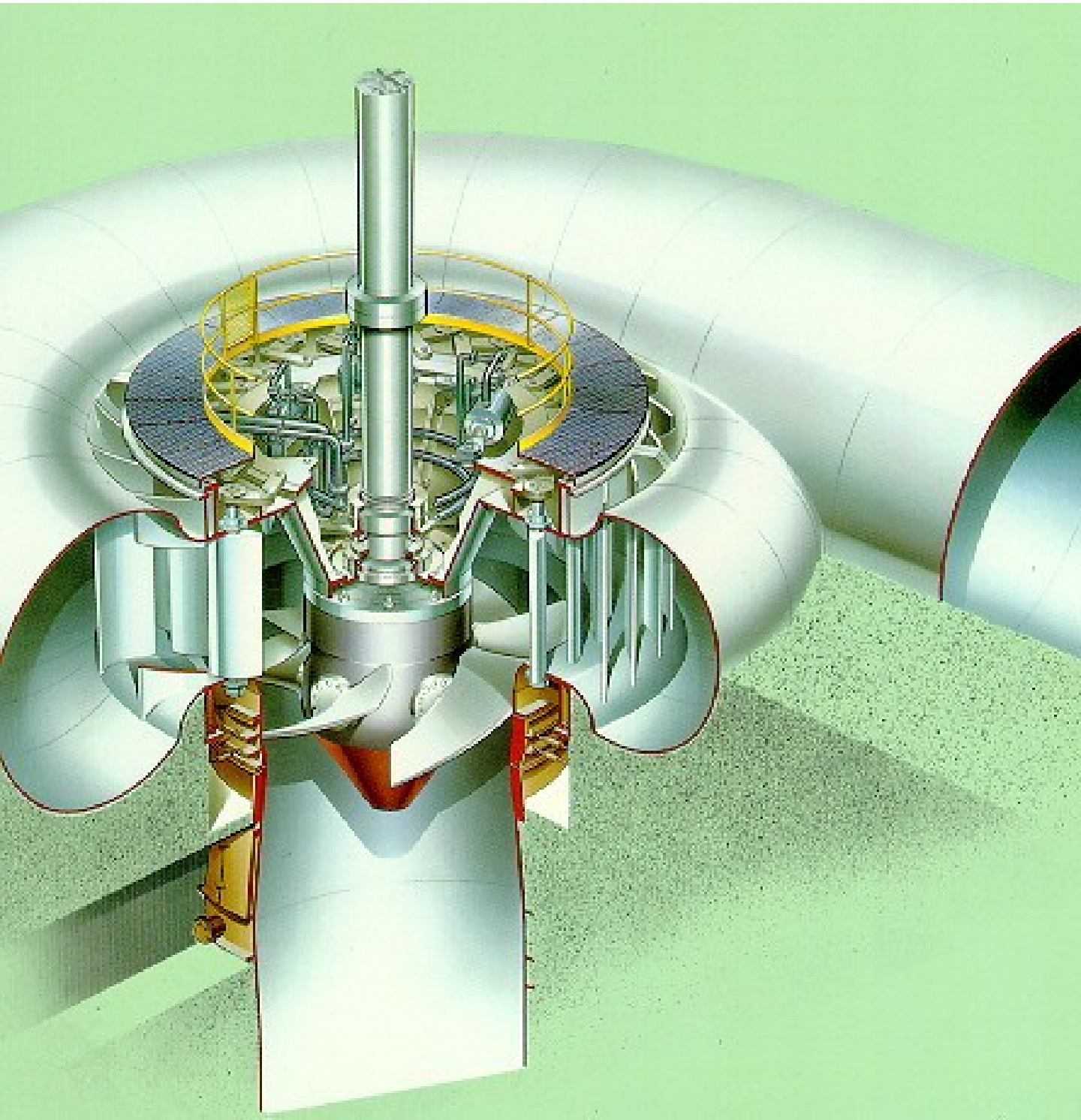
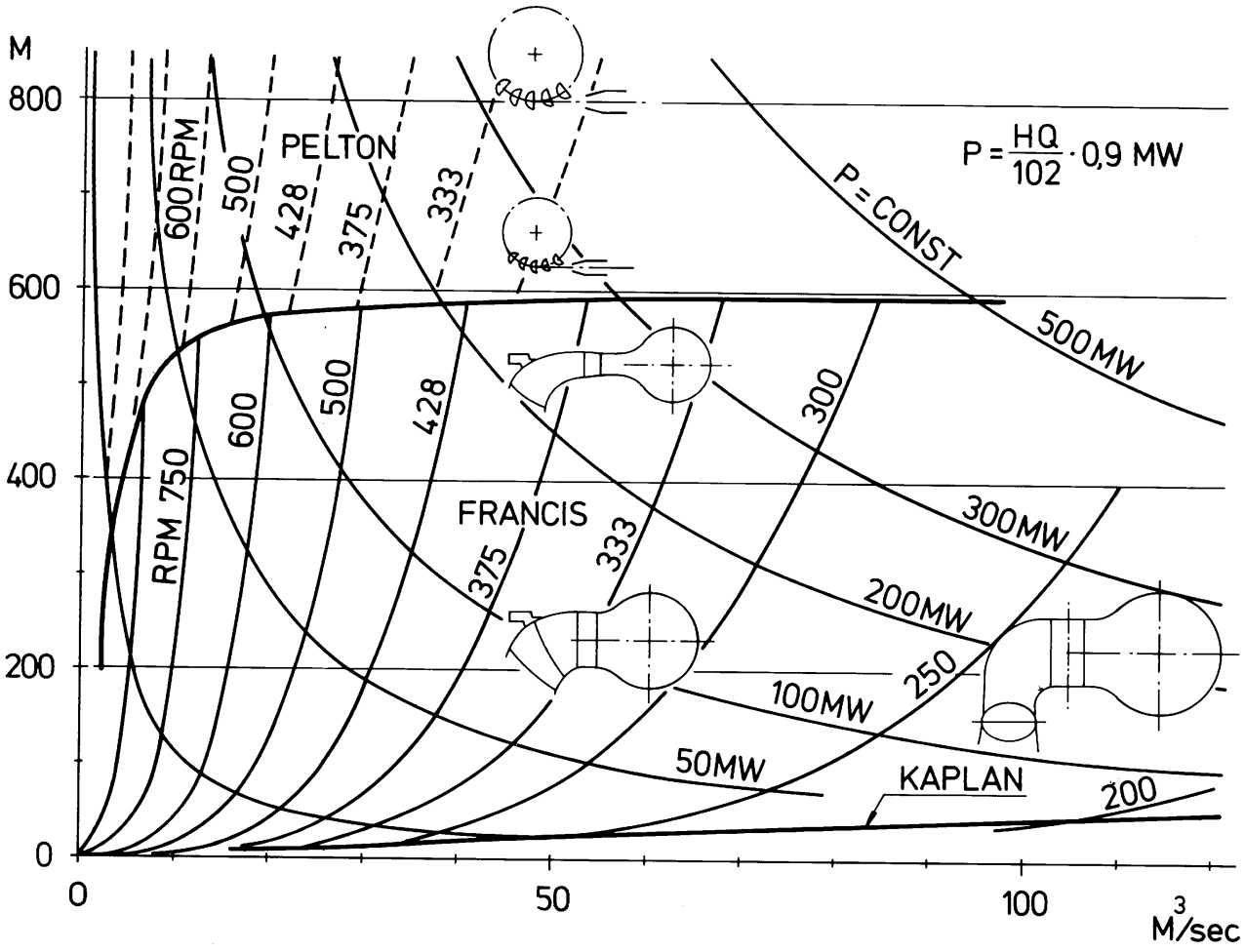
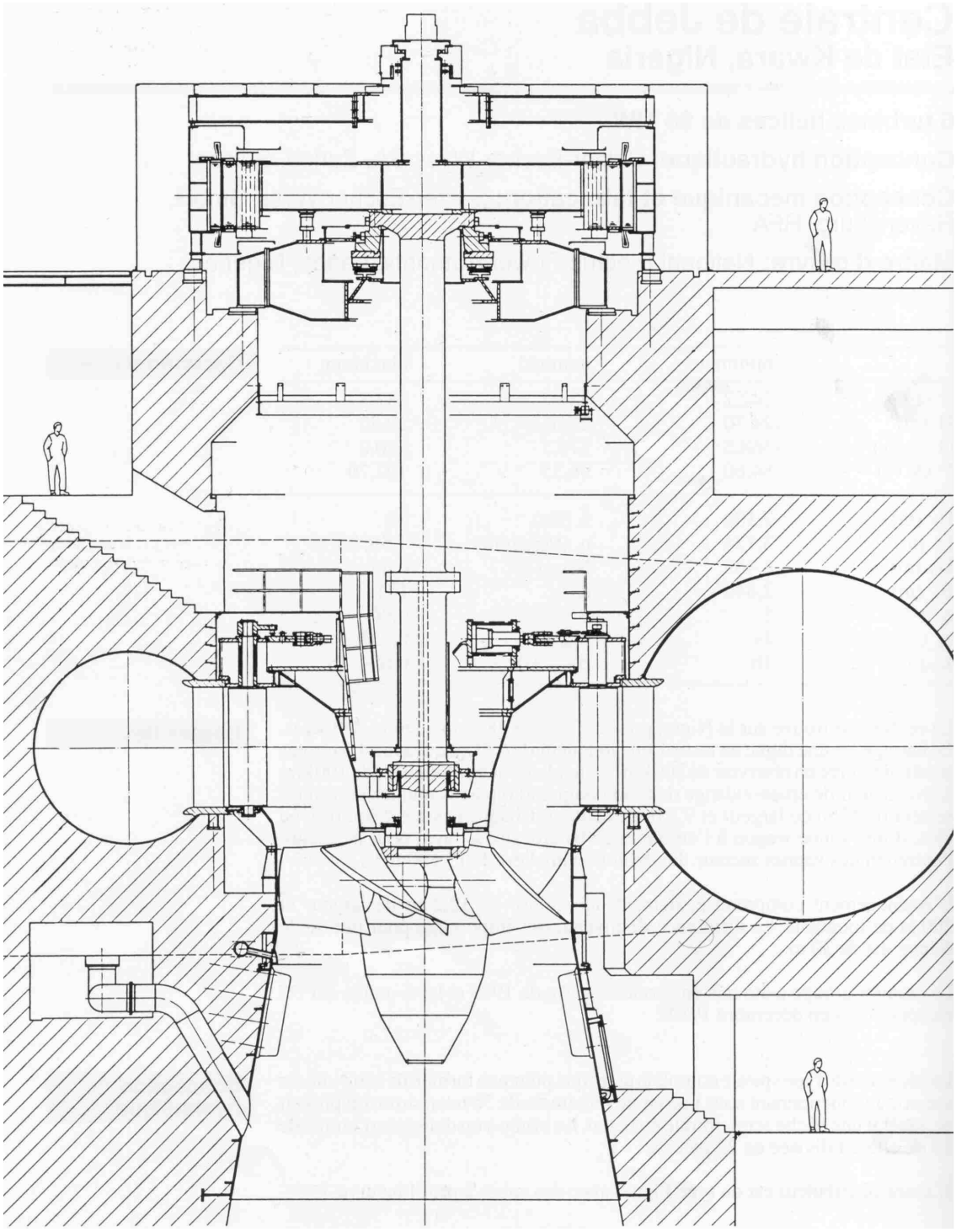
Kaplan turbine




M
800
600
400
200
0
0
50
100
M³/sec
PELTON
600RPM
500
428
375
333
P = HQ/102 · 0,9 MW
P=CONST
500MW
300MW
200MW
100MW
50MW
FRANCIS
RPM 750
600
500
428
375
333
300
250
KAPLAN
200

Jebba, Nigeria



D_0 = 8,5 m

D_e = 7,1 m

D_i = 3,1 m

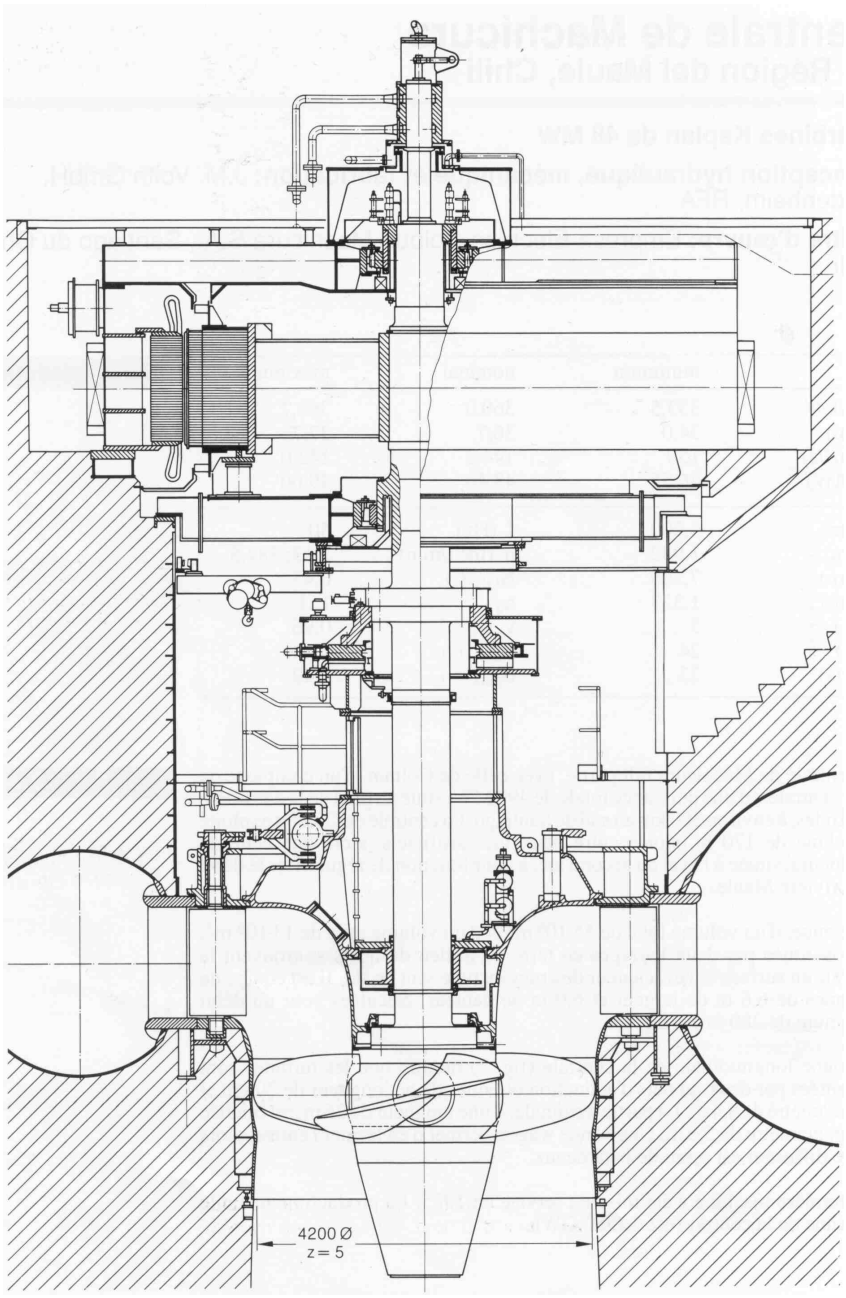
B_0 = 2,8 m

*Q = 376 m^3/s

*H = 27,6 m

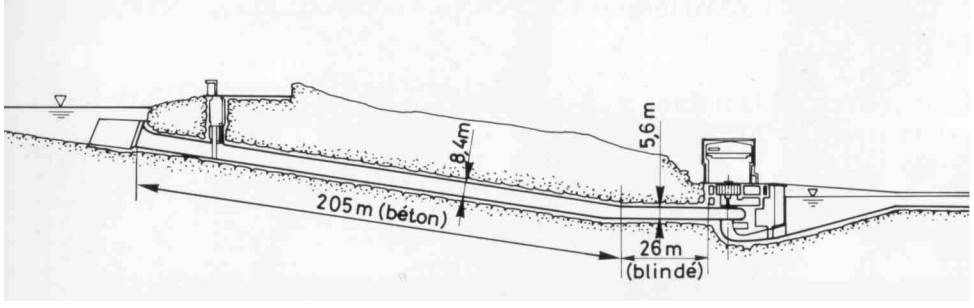
*P = 96 MW

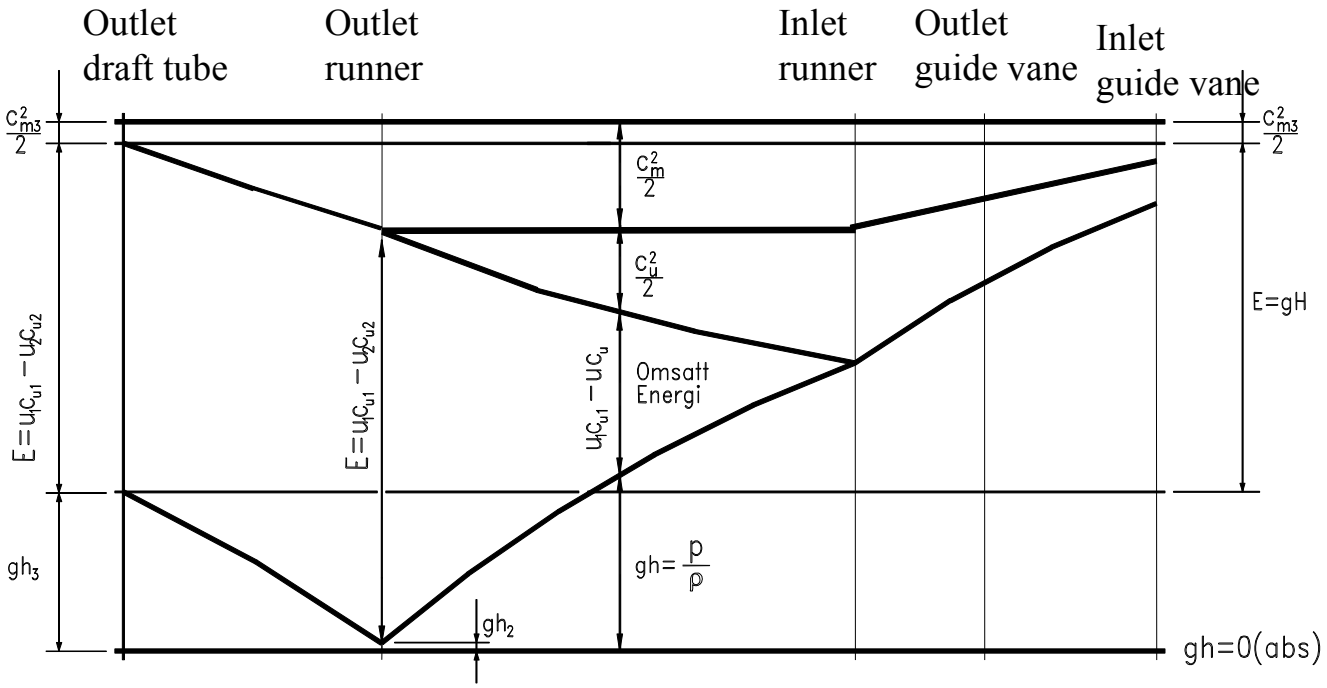
Machicura, CHILE



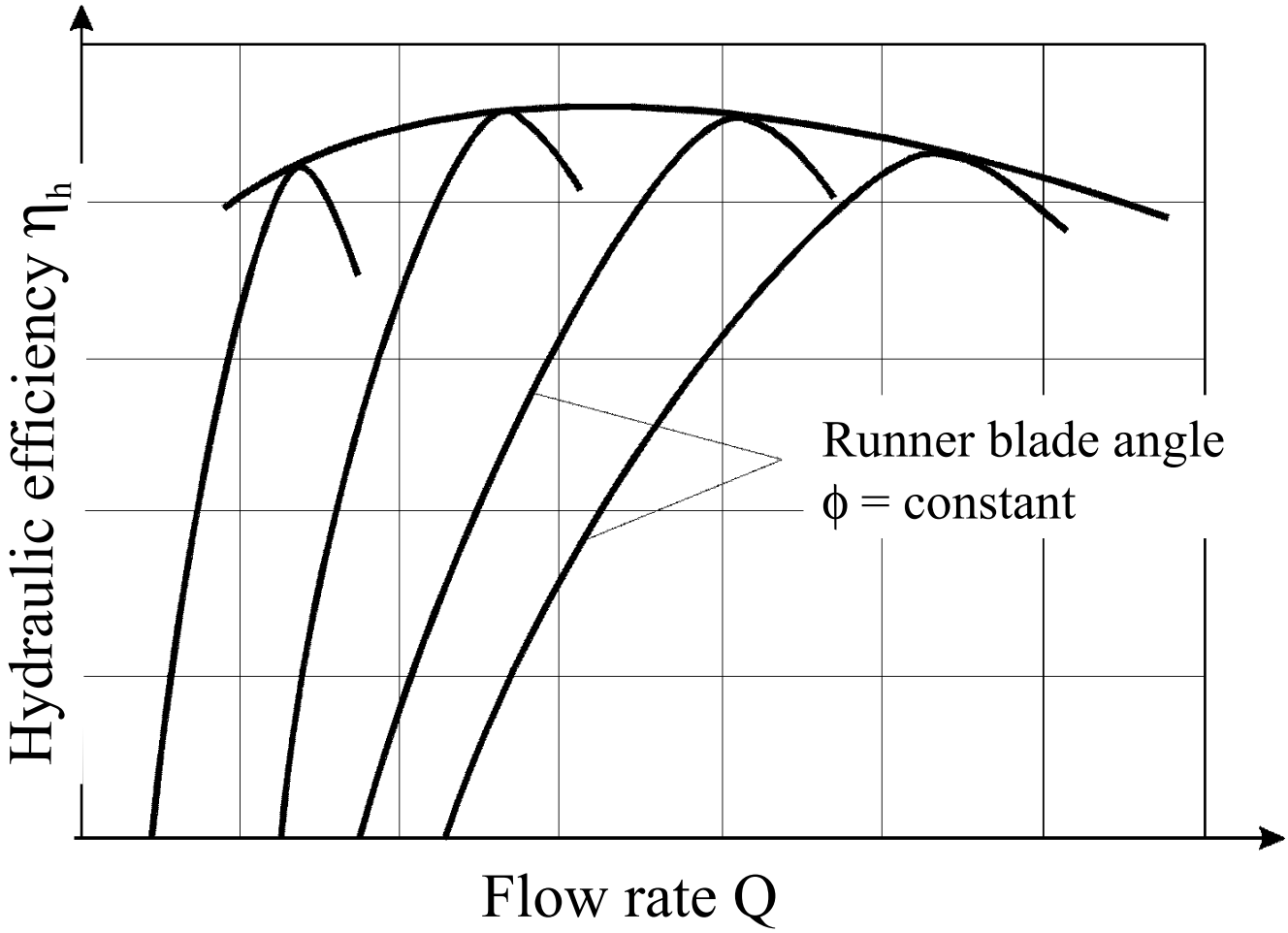
*Q = 144 m^3/s
*H = 36,7 m
*P = 48 MW

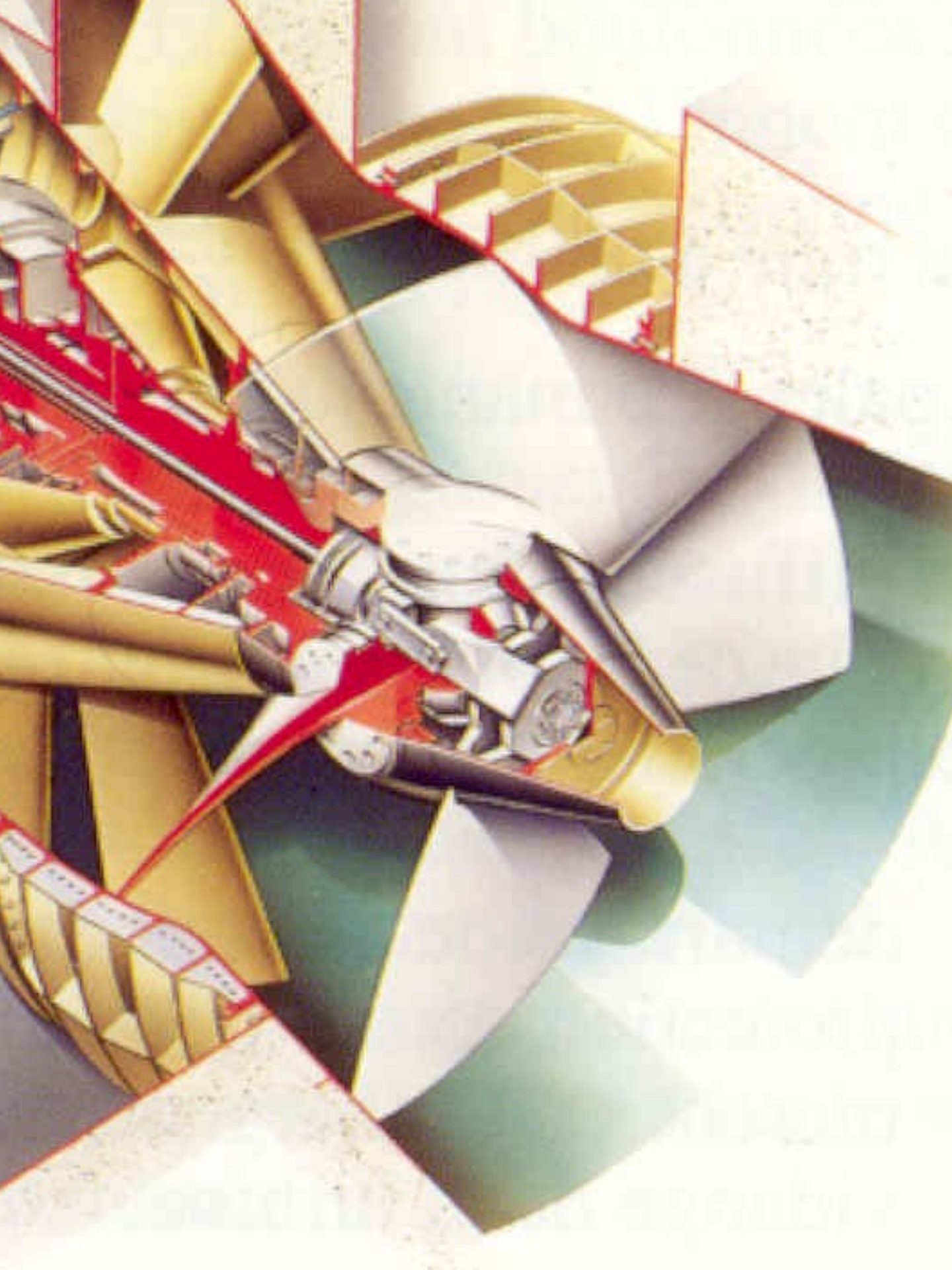
D_0 = 7,2 m
D_e = 4,2 m
D_i = 1,9 m
B_0 = 1,3 m



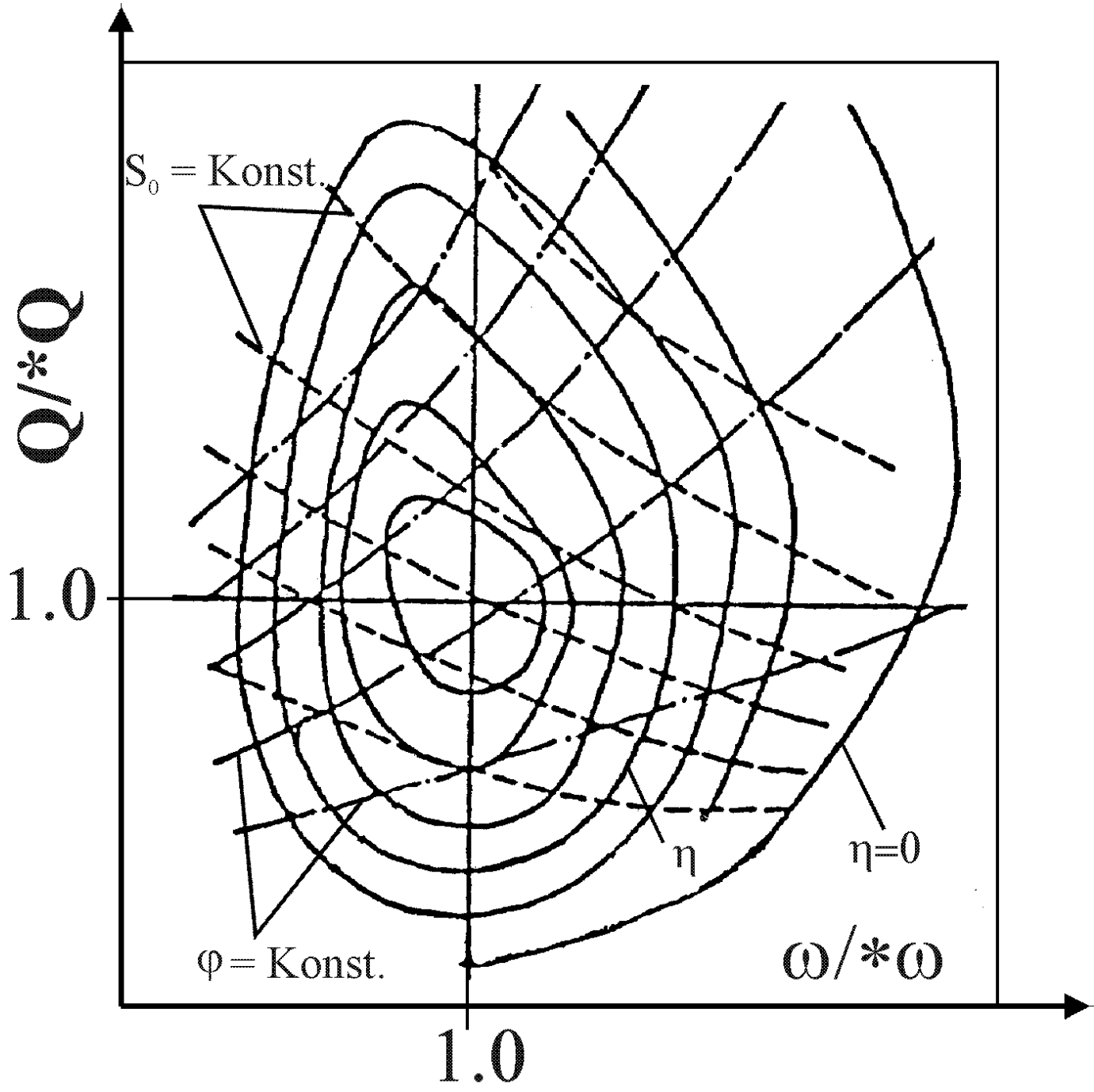

Outlet
draft tube
Outlet
runner
Inlet
runner
Outlet
guide vane
Inlet
guide vane
$\frac{c_{m3}^2}{2}$
$\frac{c_m^2}{2}$
$\frac{c_u^2}{2}$
$E=u_1c_{u1}-u_2c_{u2}$
$E=u_1c_{u1}-u_2c_{u2}$
$u_1c_{u1}-u_2c_u$
Omsatt
Energi
$E=gH$
gh_3
$gh=\frac{p}{\rho}$
gh_2
$gh=0(abs)$

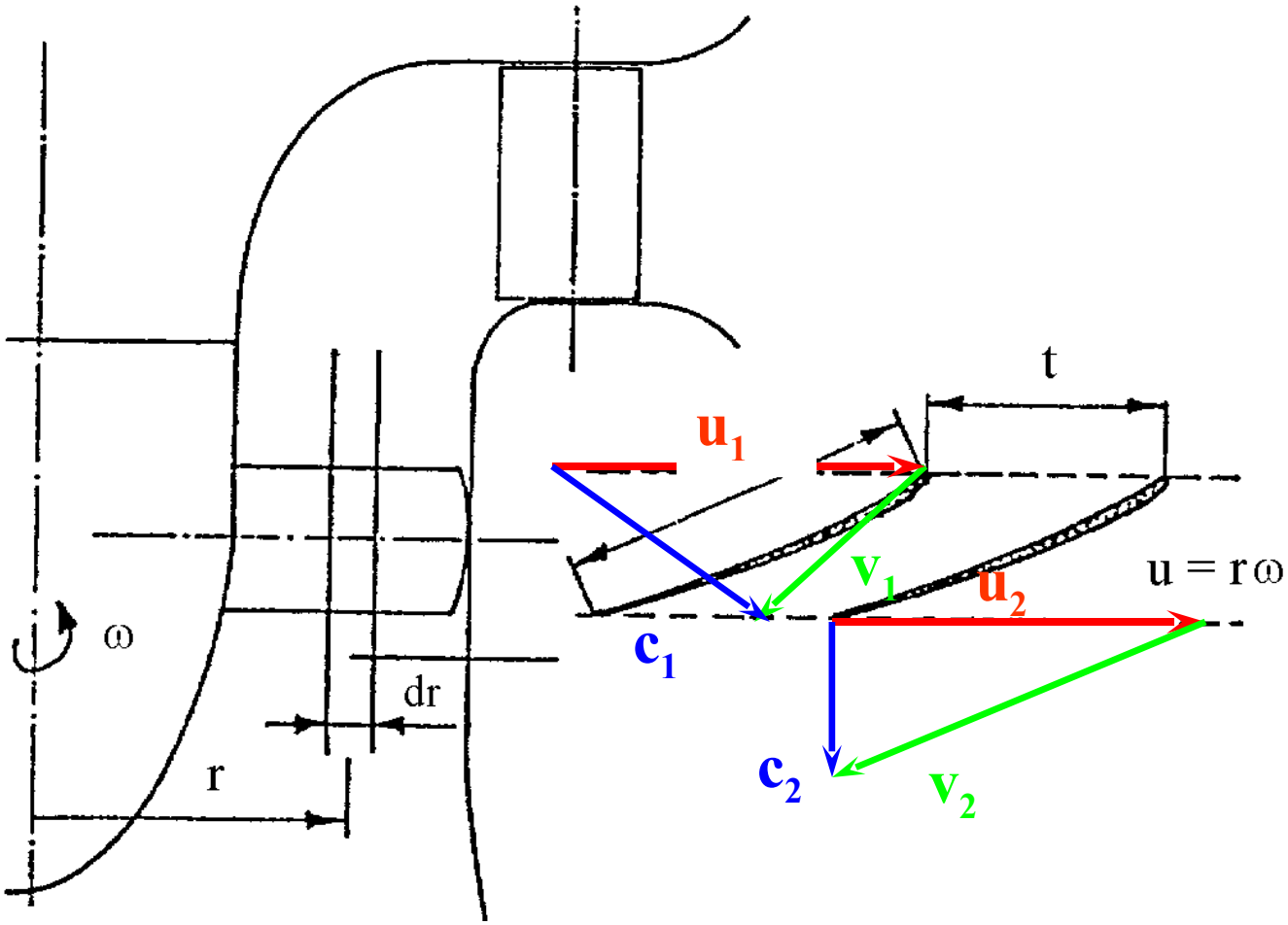
Hydraulic efficiency





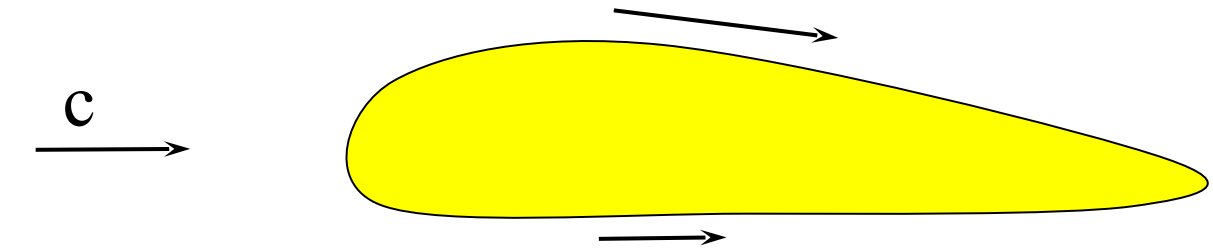
Hill chart

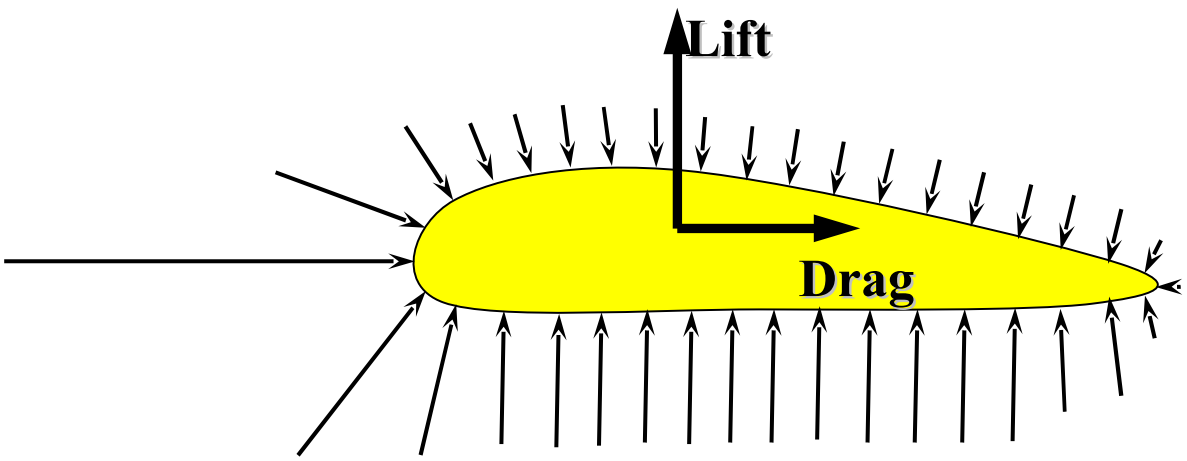


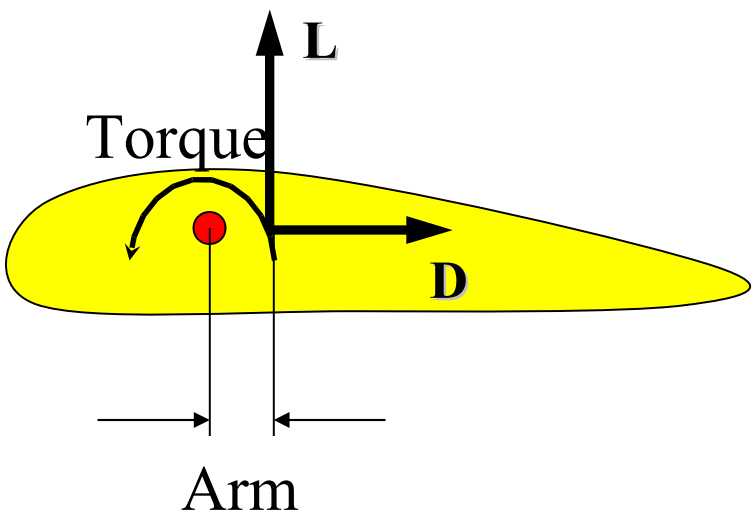


$$\eta_h = \frac{u_1 \cdot c_{u1} - u_2 \cdot c_{u2}}{g \cdot H}$$

Pressure distribution and torque

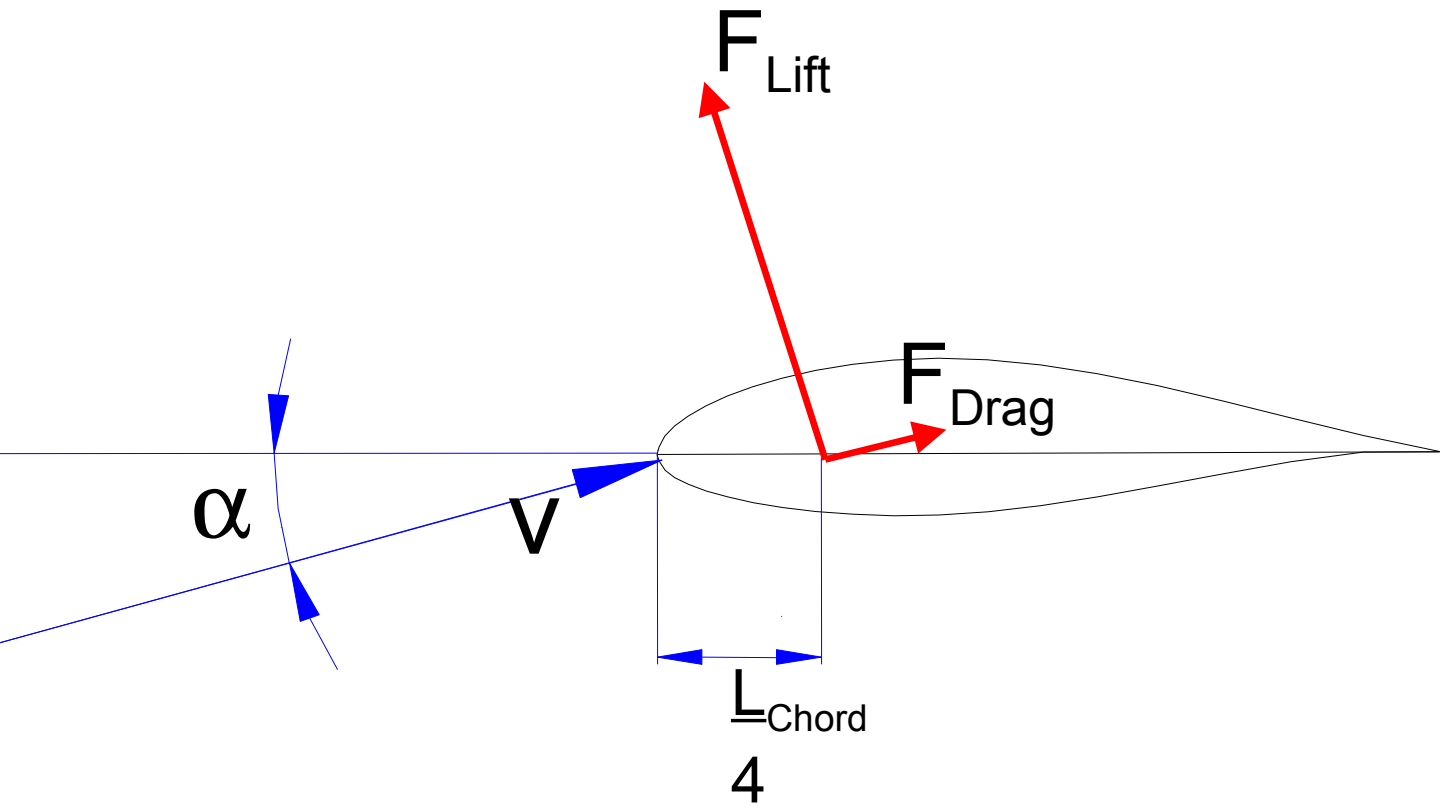




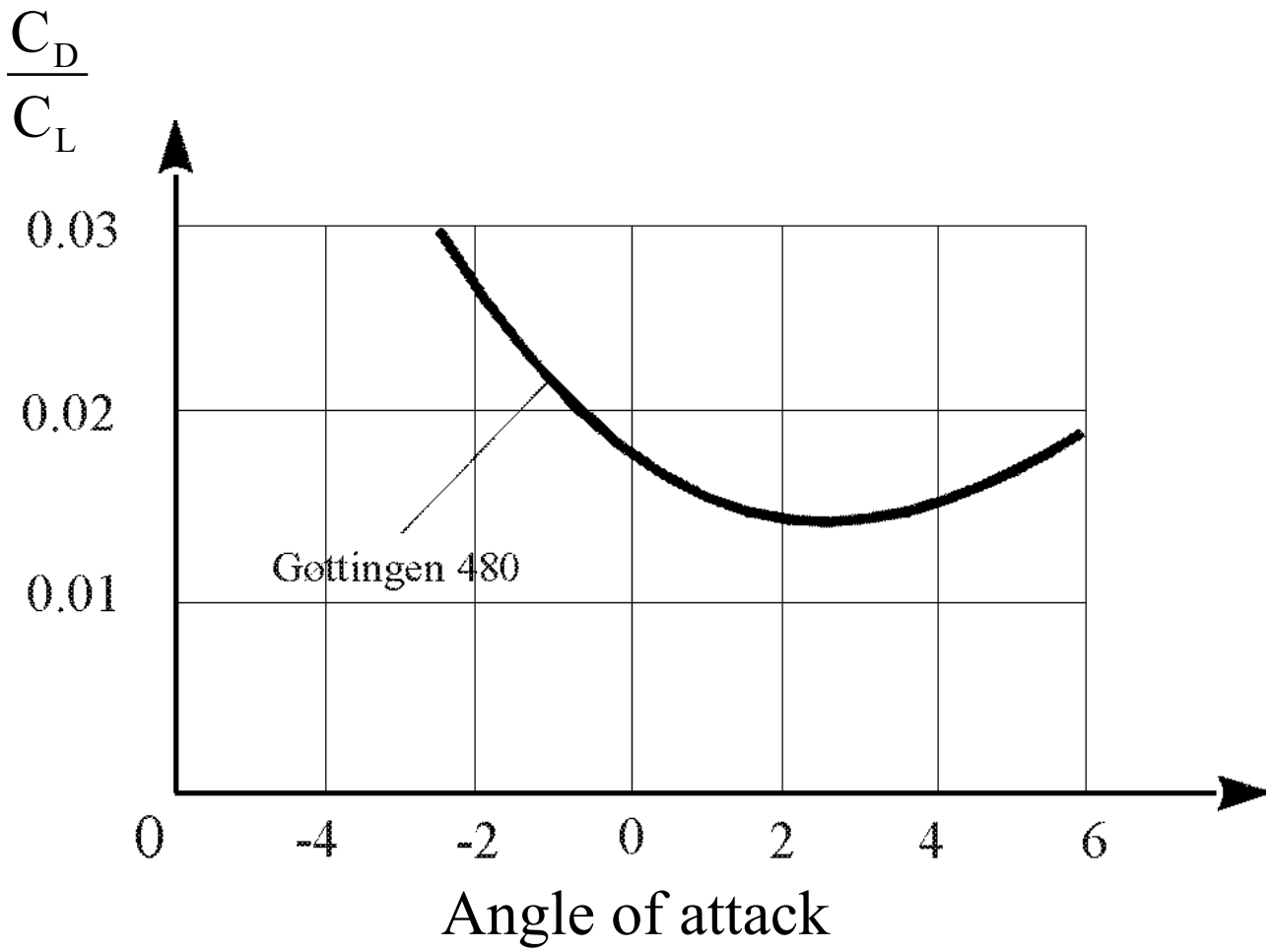


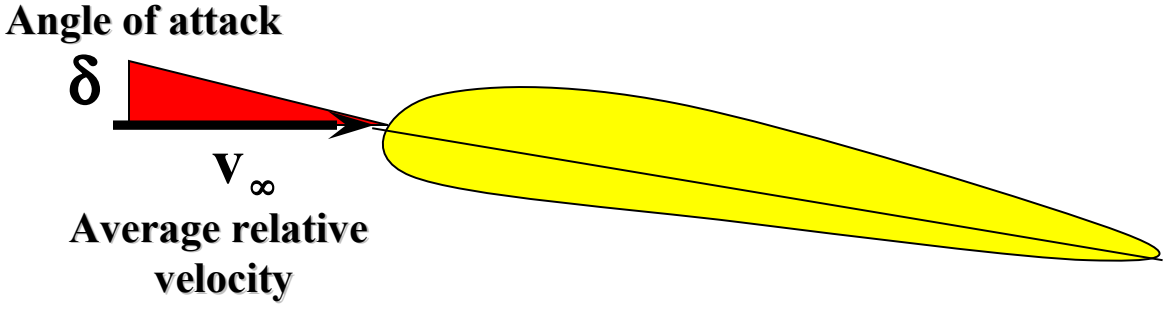
$$F_L = C_L \cdot \frac{1}{2} \cdot \rho \cdot V^2 \cdot A$$

$$F_D = C_D \cdot \frac{1}{2} \cdot \rho \cdot V^2 \cdot A$$

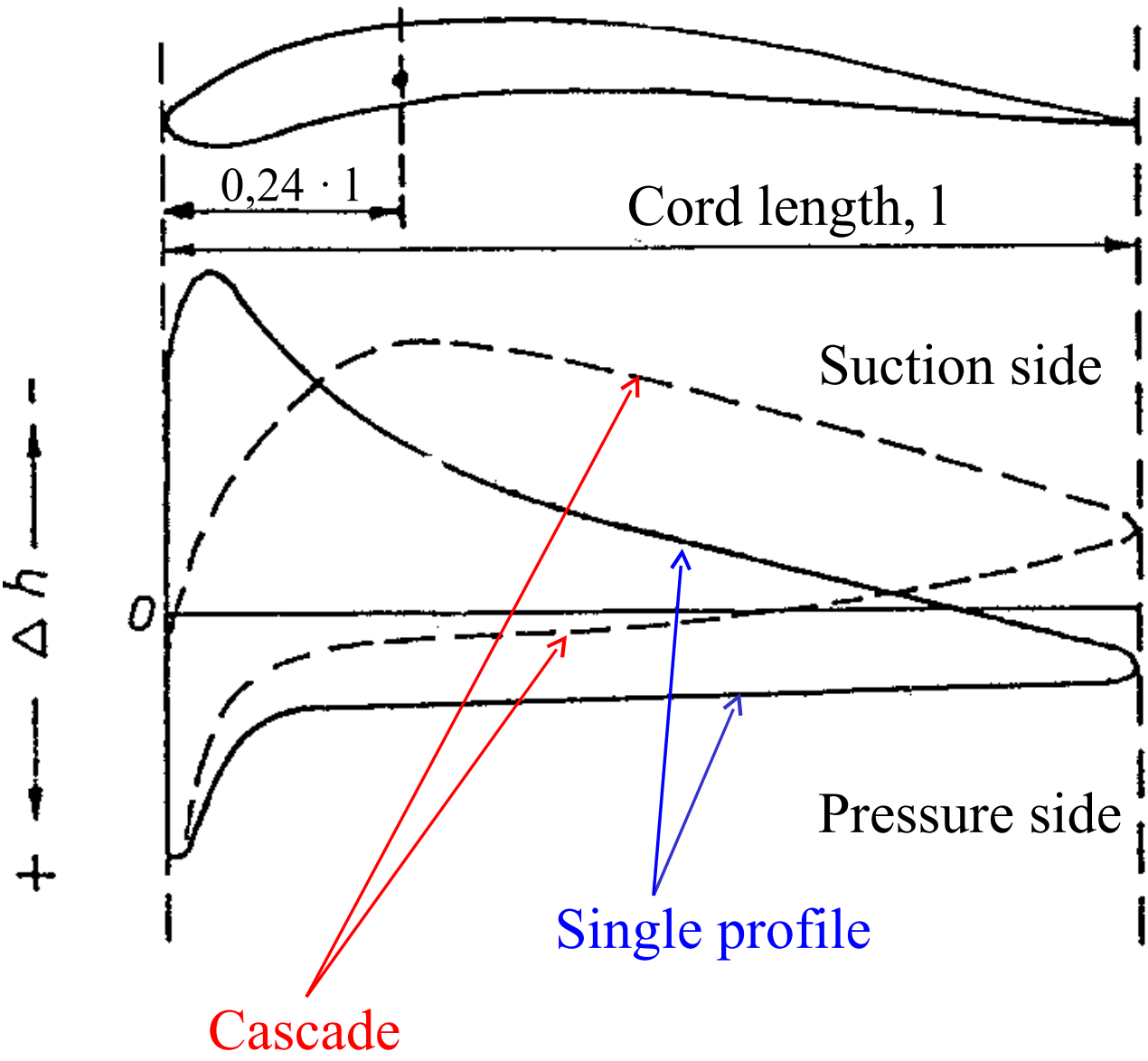


Blade profile data



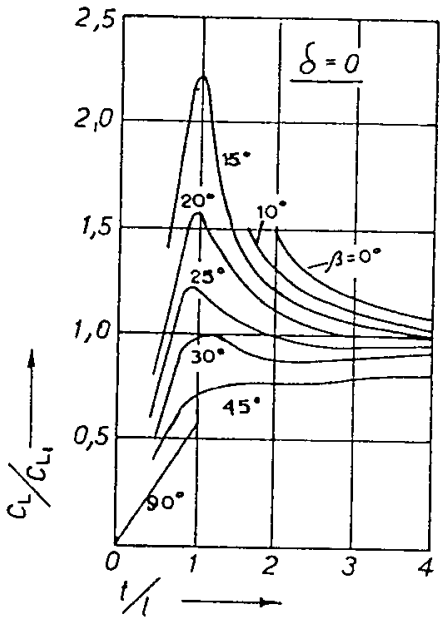


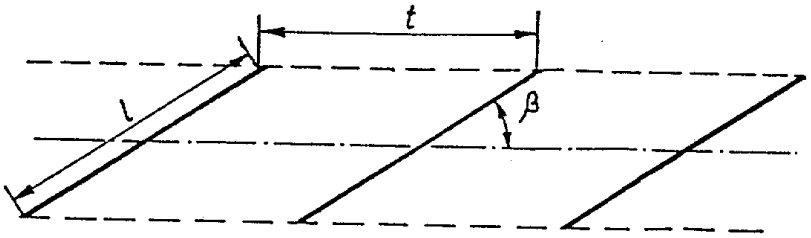
Pressure distribution and torque



The pressure at the outlet is lower for a cascade than for a single profile. The cavitation performance will therefore be reduced in a cascade.

Radial distribution of the blade profile



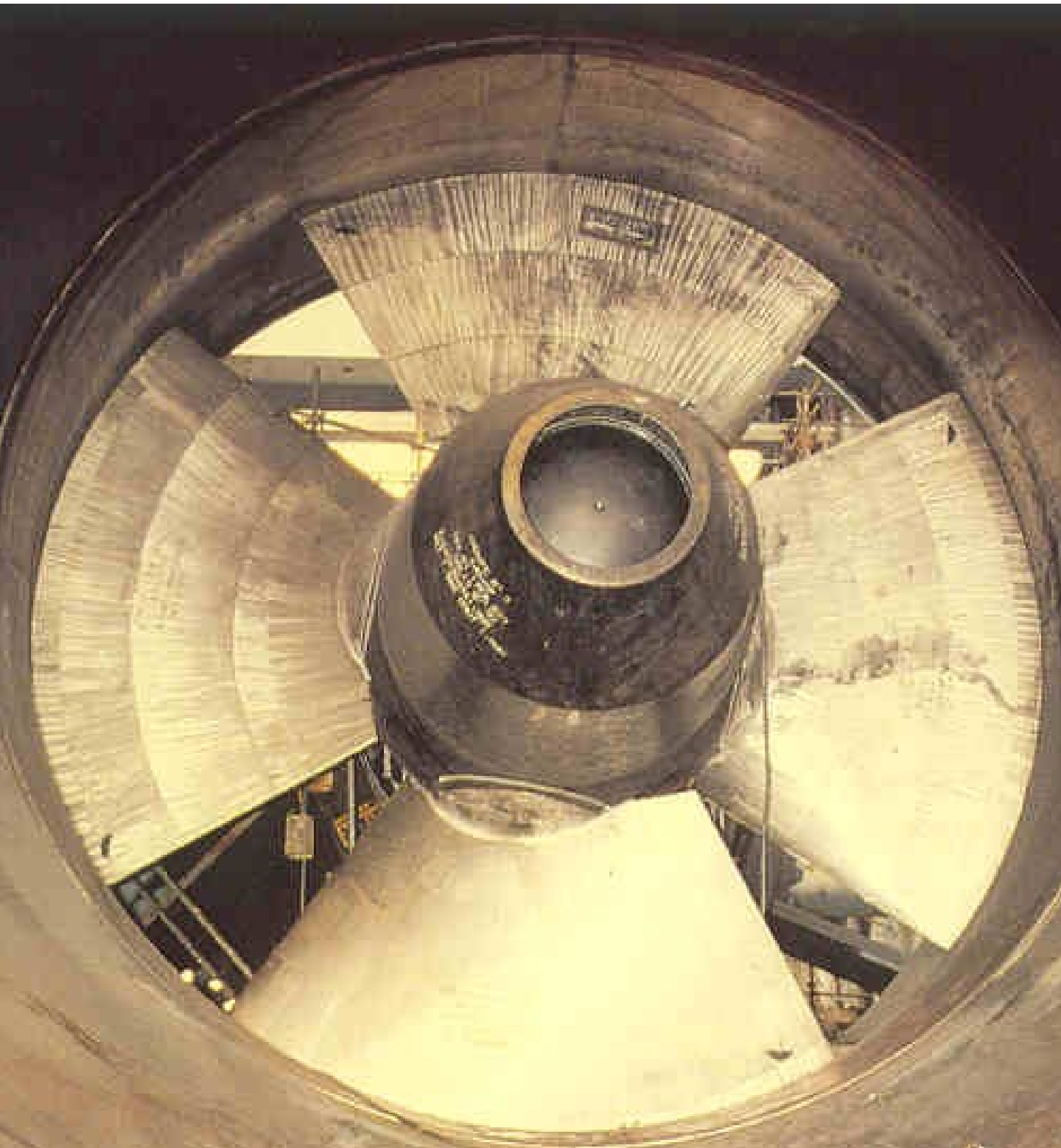


C_L =Lift coefficient for a cascade

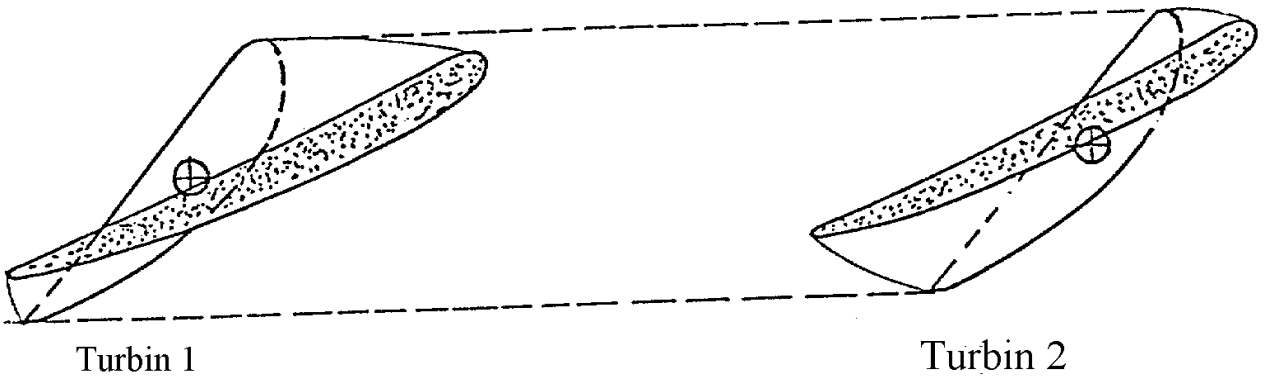
C_{L1} =Lift coefficient for a single profile

The ratio t/l influences the lift coefficient in a cascade. The cord length for a blade will therefore increase when the radius becomes increase

Radial distribution of the blade profile

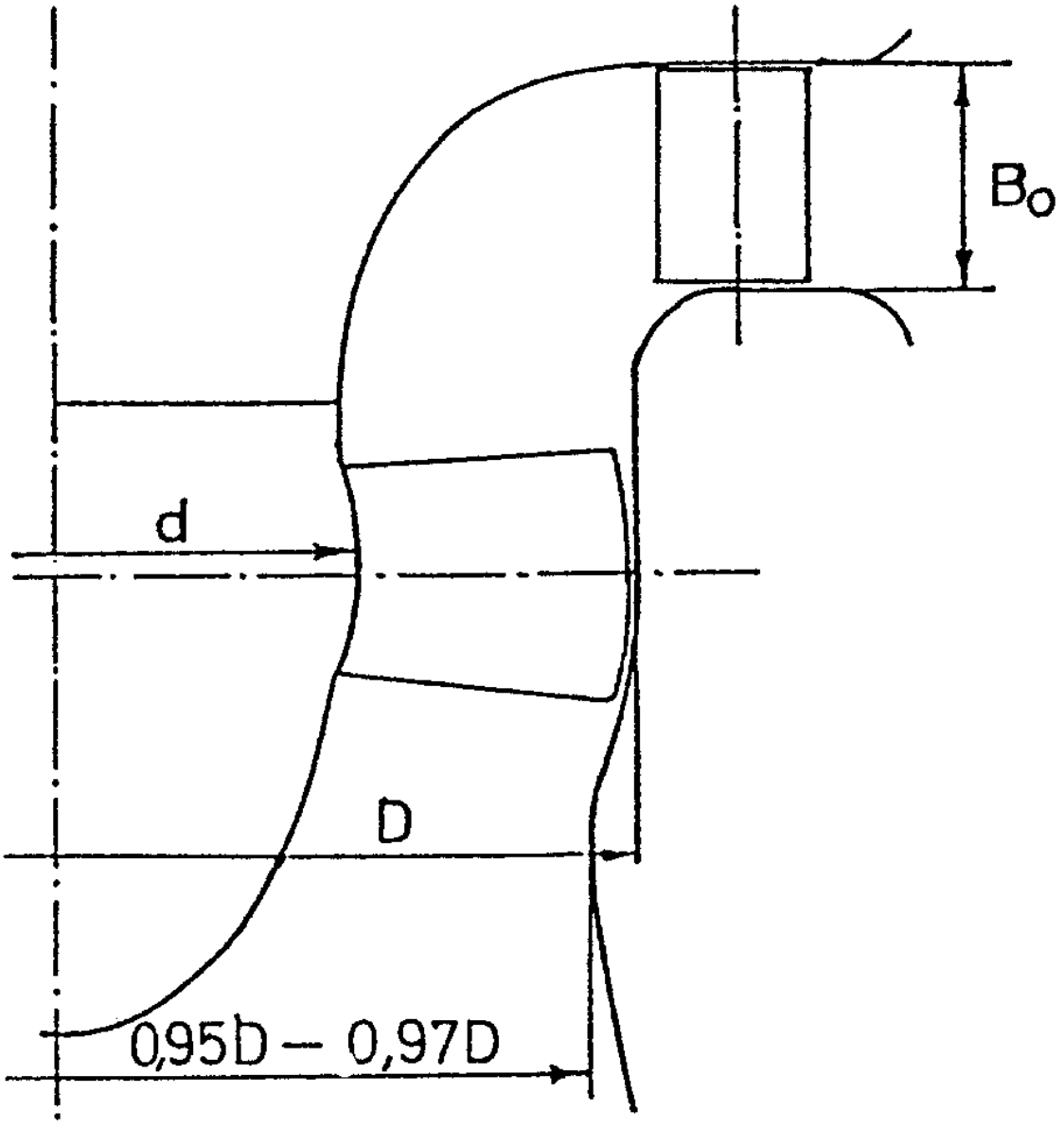


Flow in the axial plane



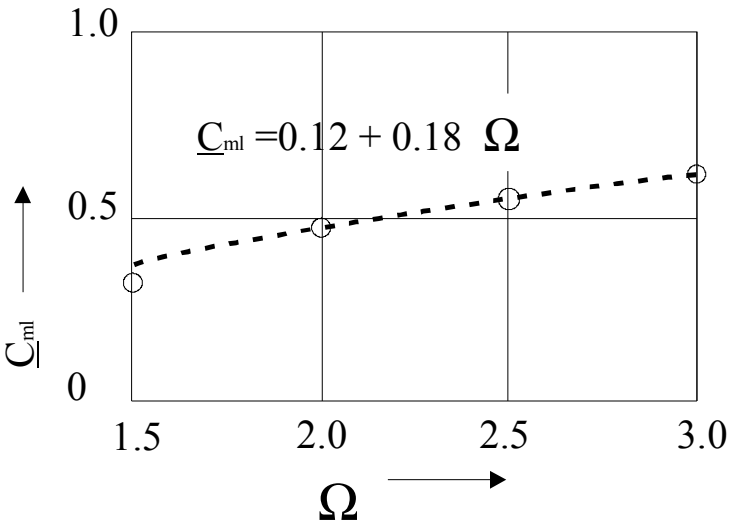
The figure shows blades with two different design of the blade in radial direction. This is because it will influence the secondary flow in the radial direction

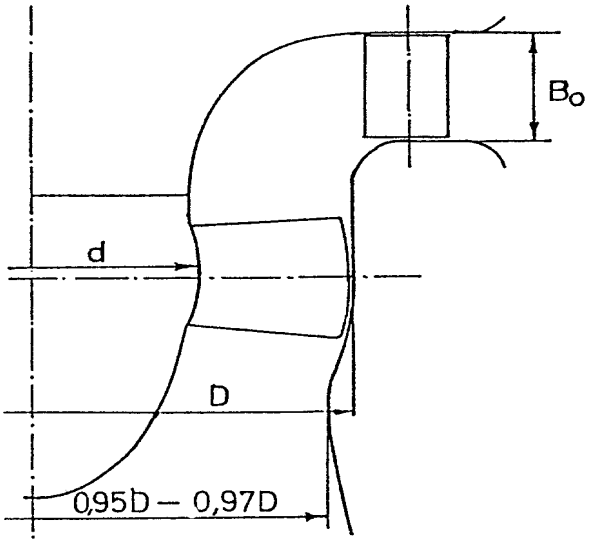
Main dimension of a Kaplan turbine



Diameter of the runner

$$^{o}\Omega = \underline{\omega} \cdot \sqrt{\underline{Q}_n}$$





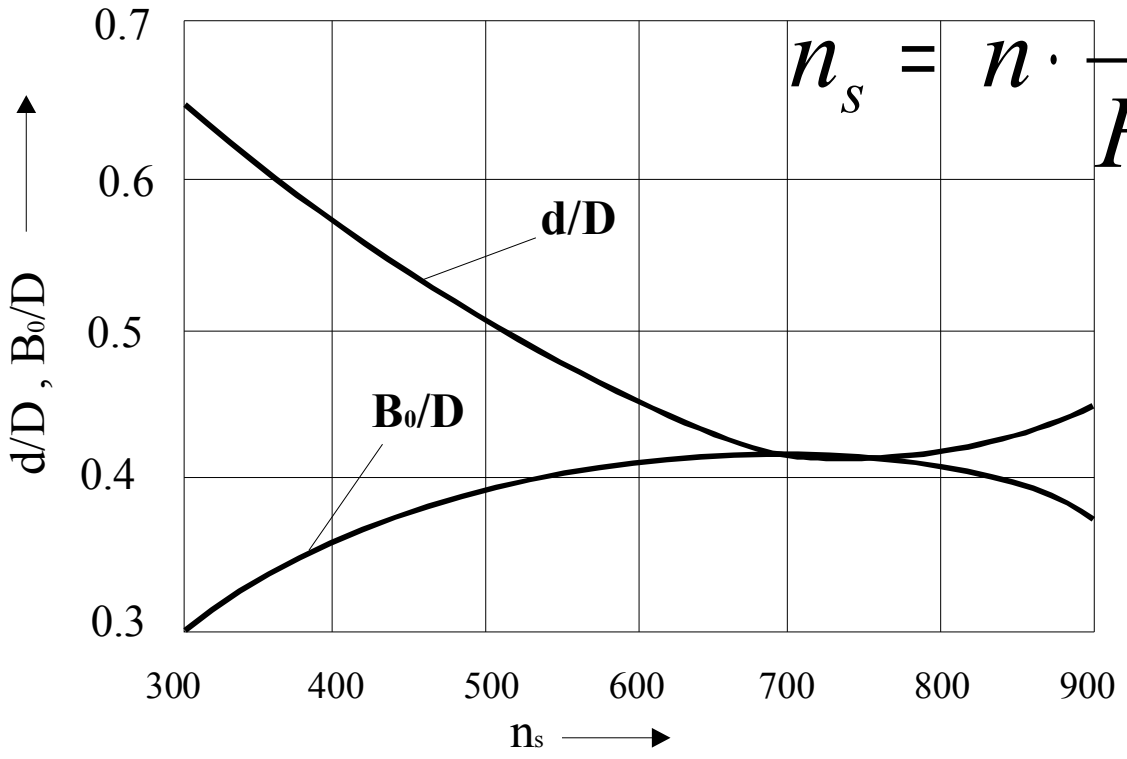
$$\underline{Q}_n = \frac{\Pi \cdot \left(D^2 - d^2\right)}{4} \cdot \underline{c}_{1m}$$

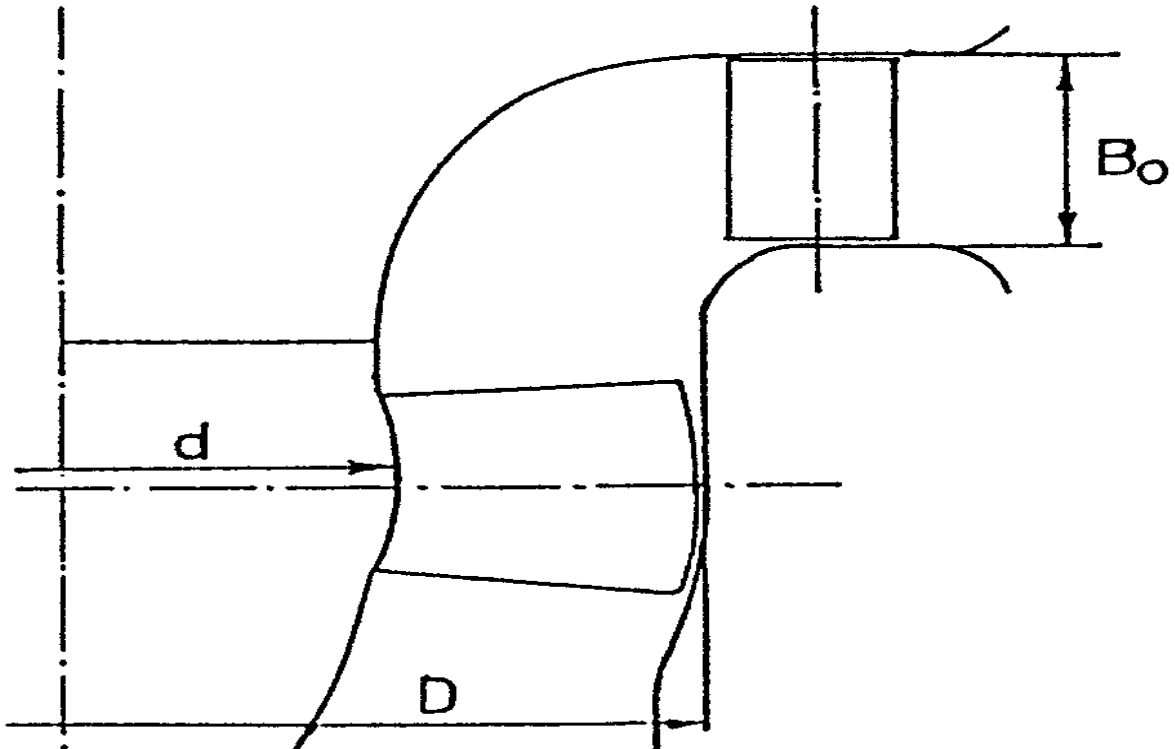
$$\Downarrow$$

$$D = \sqrt{\frac{\underline{Q}_n \cdot 4}{\Pi \cdot \underline{c}_{1m}}}$$

Height of the guide vanes and runner diameter

$$n_s = n \cdot \frac{\sqrt{P}}{H_n^{5/4}}$$

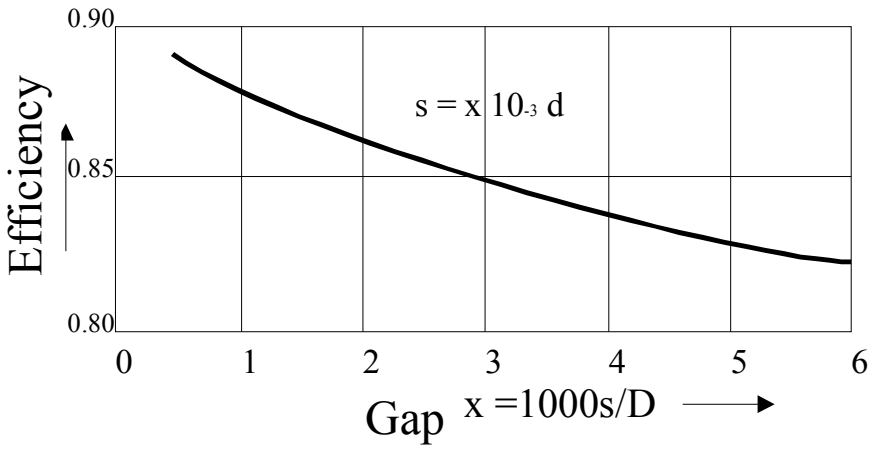




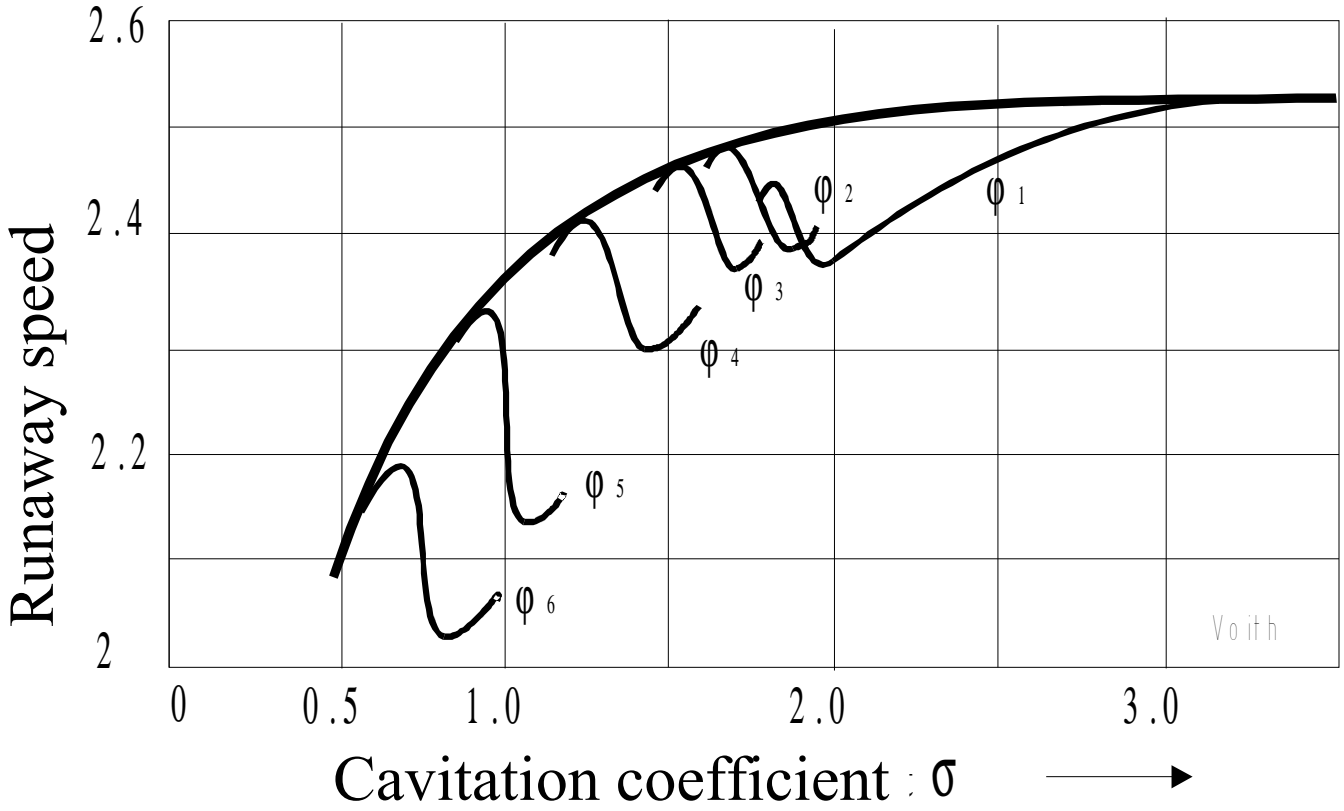
Gap between hub and ring and the runner blades

Gap between the blade and ring

Gap between the blade and hub



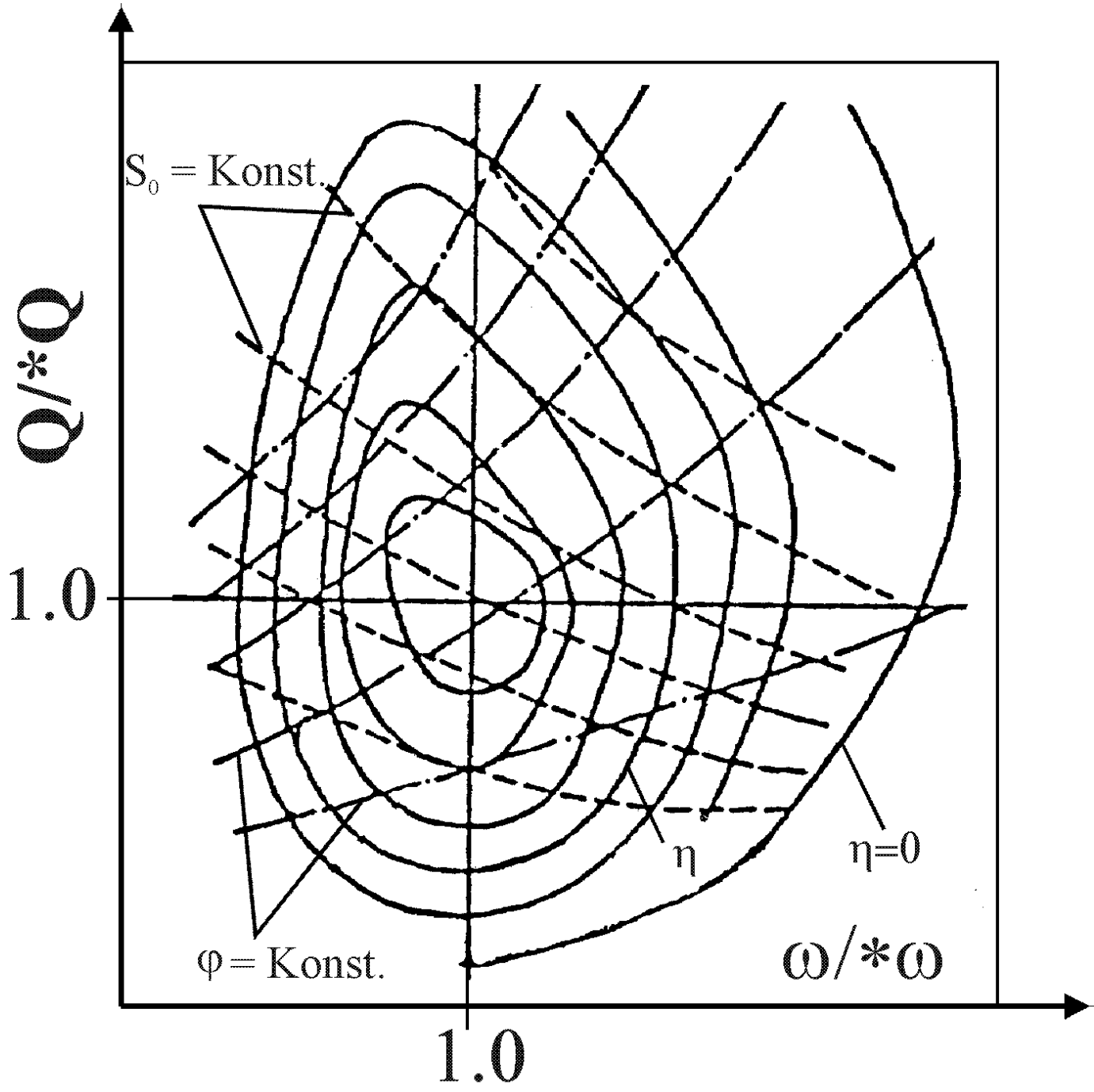
Runaway speed



$$\sigma = \frac{10 - H_S}{H}$$

The figure shows different runaway speed at different runner blade openings. The runaway speed is dependent of the cavitation as shown in the figure

Hill chart

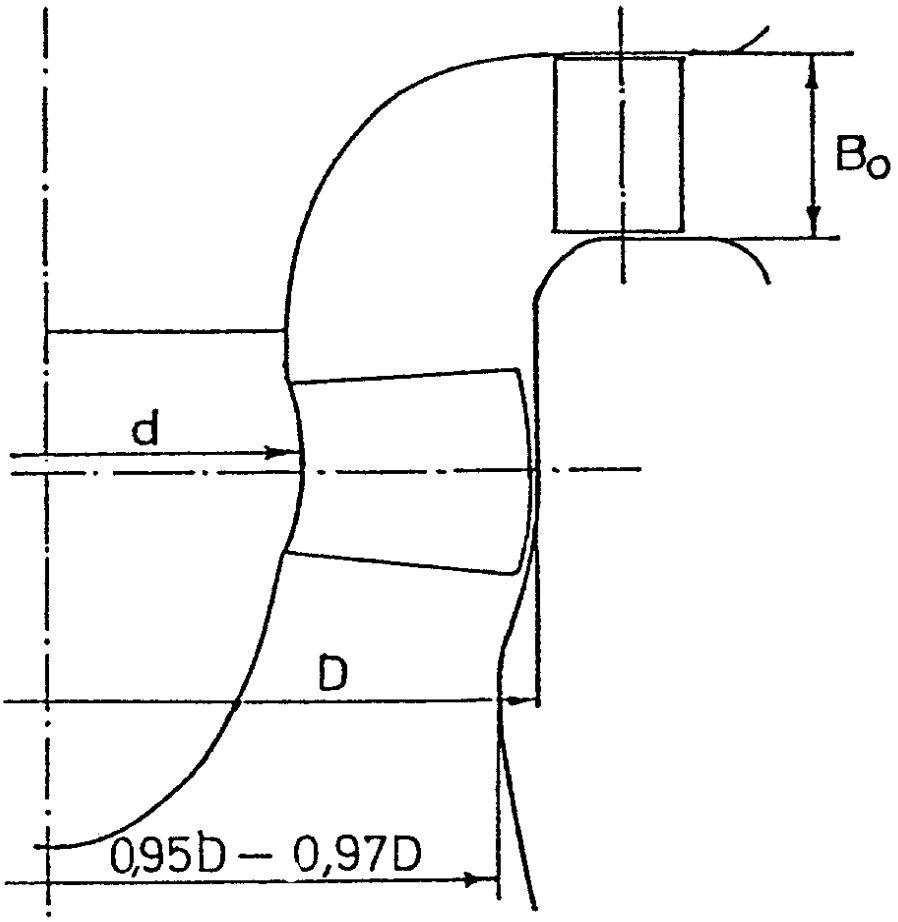


Example

- Find the dimensions D, d and B_o

- Given data:

$P = 16{,}8$ MW
$H = 16$ m
$Q_n = 120\ m^3/s$
$n = 125$ rpm



Speed number:

$$\sqrt{2 \cdot g \cdot H} = \sqrt{2 \cdot 9{,}82 \cdot 16} = 17{,}7 \text{ m/s}$$

$$\omega = \frac{n \cdot 2 \cdot \Pi}{60} = \frac{125 \cdot 2 \cdot \Pi}{60} = 13{,}1 \text{ rad/s}$$

$$\underline{\omega} = \frac{\omega}{\sqrt{2 \cdot g \cdot H}} = \frac{13{,}1 \text{ rad/s}}{17{,}7 \text{ m/s}} = 0{,}74 \text{ m}^{-1}$$

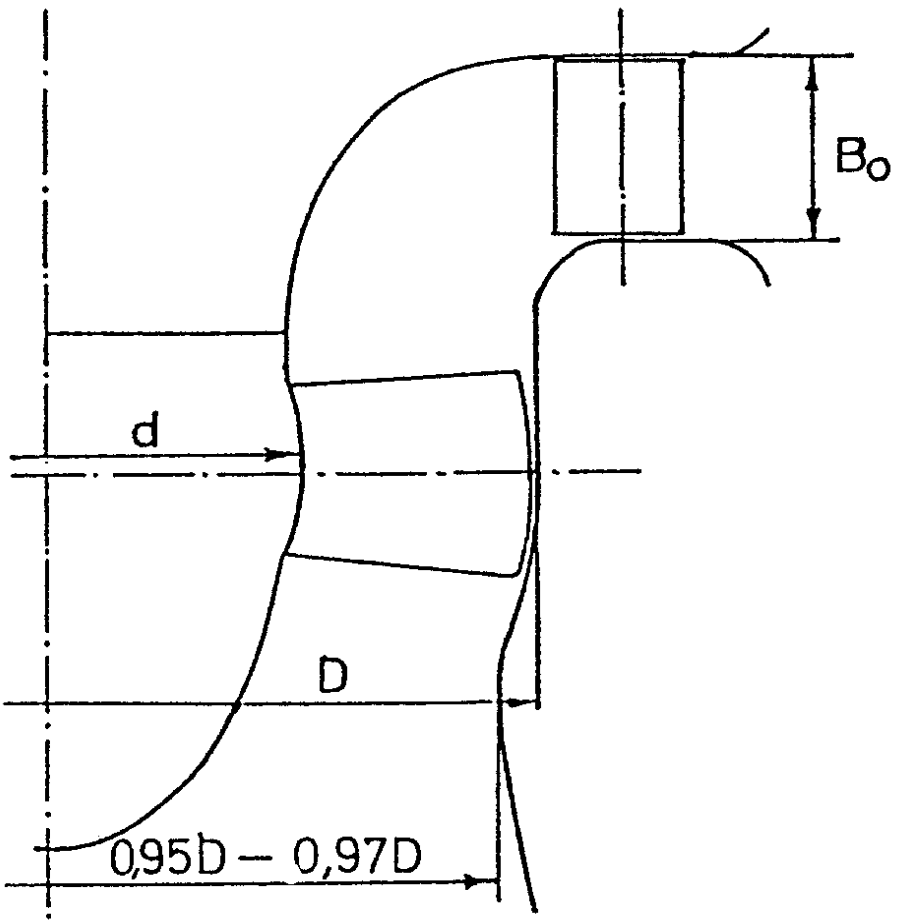
$$\underline{Q}_n = \frac{Q}{\sqrt{2 \cdot g \cdot H}} = \frac{120 \text{ m}^3/\text{s}}{17{,}7 \text{ m/s}} = 6{,}78 \text{ m}^2$$

$$^{o}\Omega = \underline{\omega} \cdot \sqrt{\underline{Q}_n} = 0{,}74 \cdot \sqrt{6{,}78} = 1{,}93$$

Diameter, D:

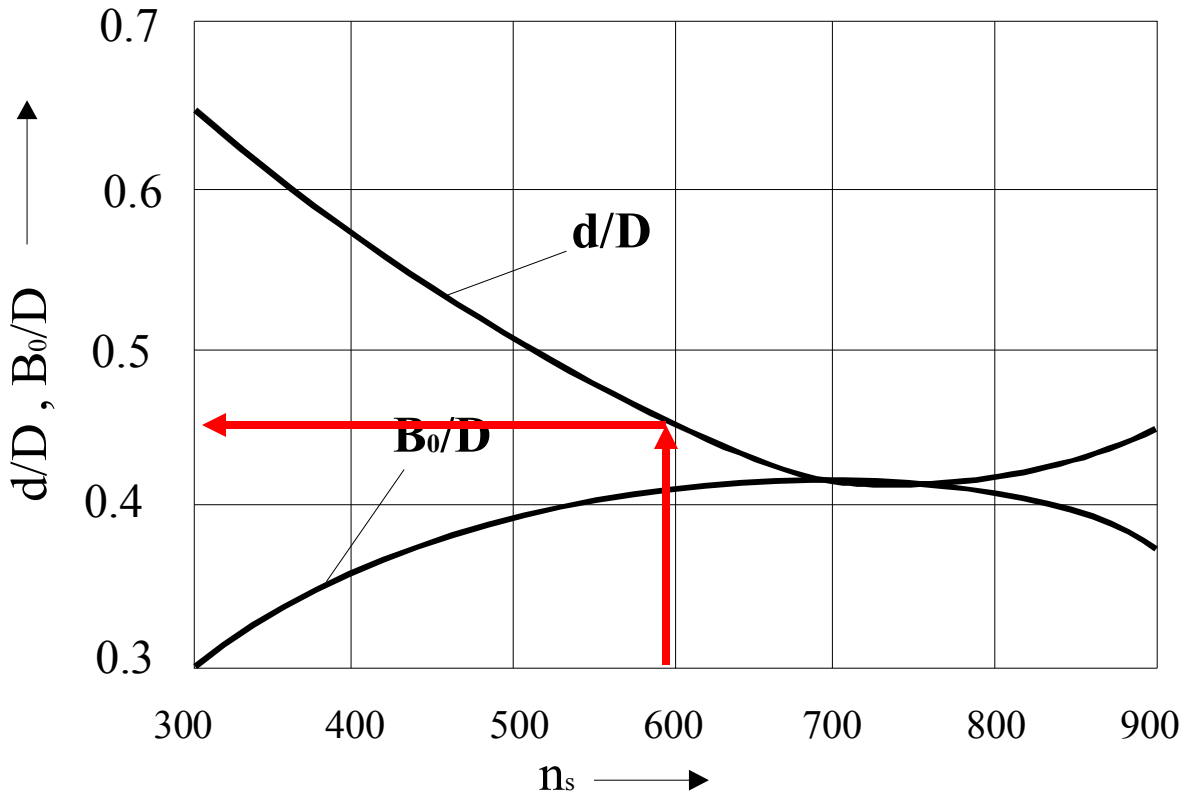
$$\underline{c}_{1m} = 0{,}12 + 0{,}18 \cdot {}^{o}\Omega = 0{,}467$$

$$D = \sqrt{\frac{\underline{Q}_n \cdot 4}{\Pi \cdot \underline{c}_{1m}}} = \sqrt{\frac{6{,}78 \cdot 4}{\Pi \cdot 0{,}467}} = 4{,}3\ m$$



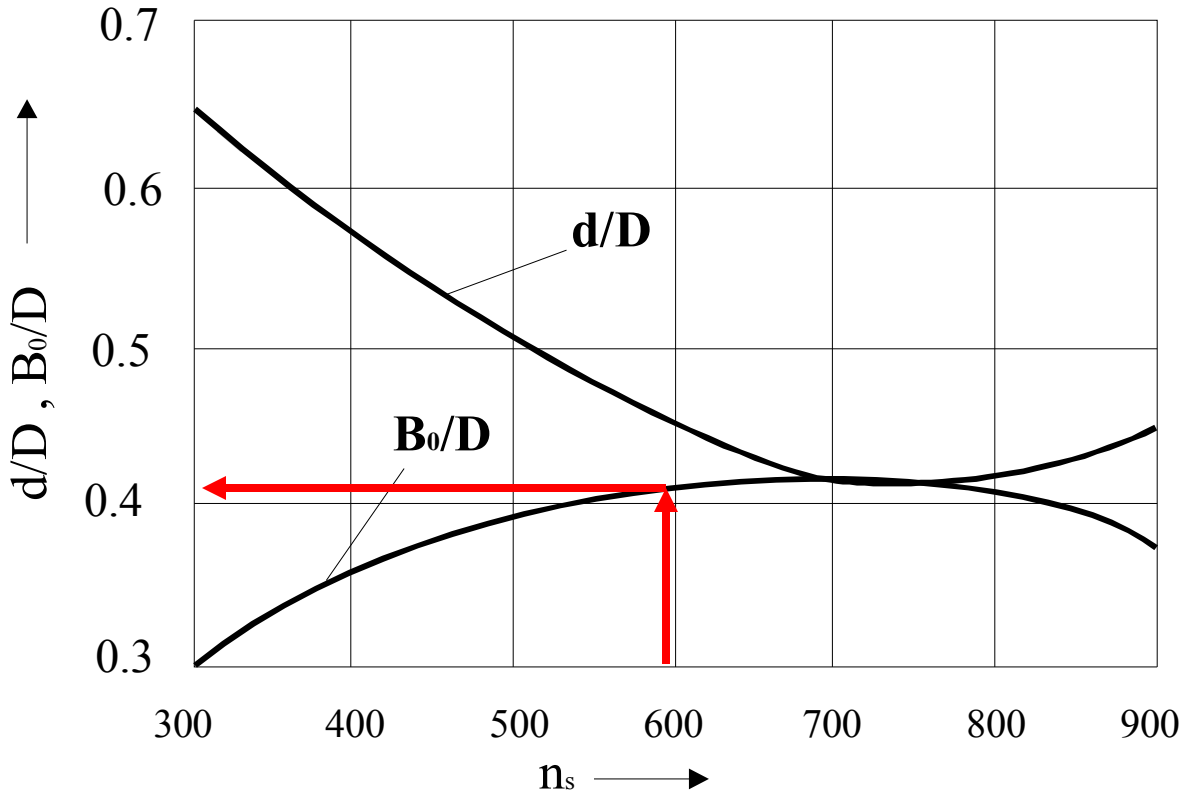
Diameter, d:

$$n_s = n \cdot \frac{\sqrt{P}}{H_n^{5/4}} = 125rpm \cdot \frac{\sqrt{22826\ Hp}}{16m^{5/4}} = 590$$



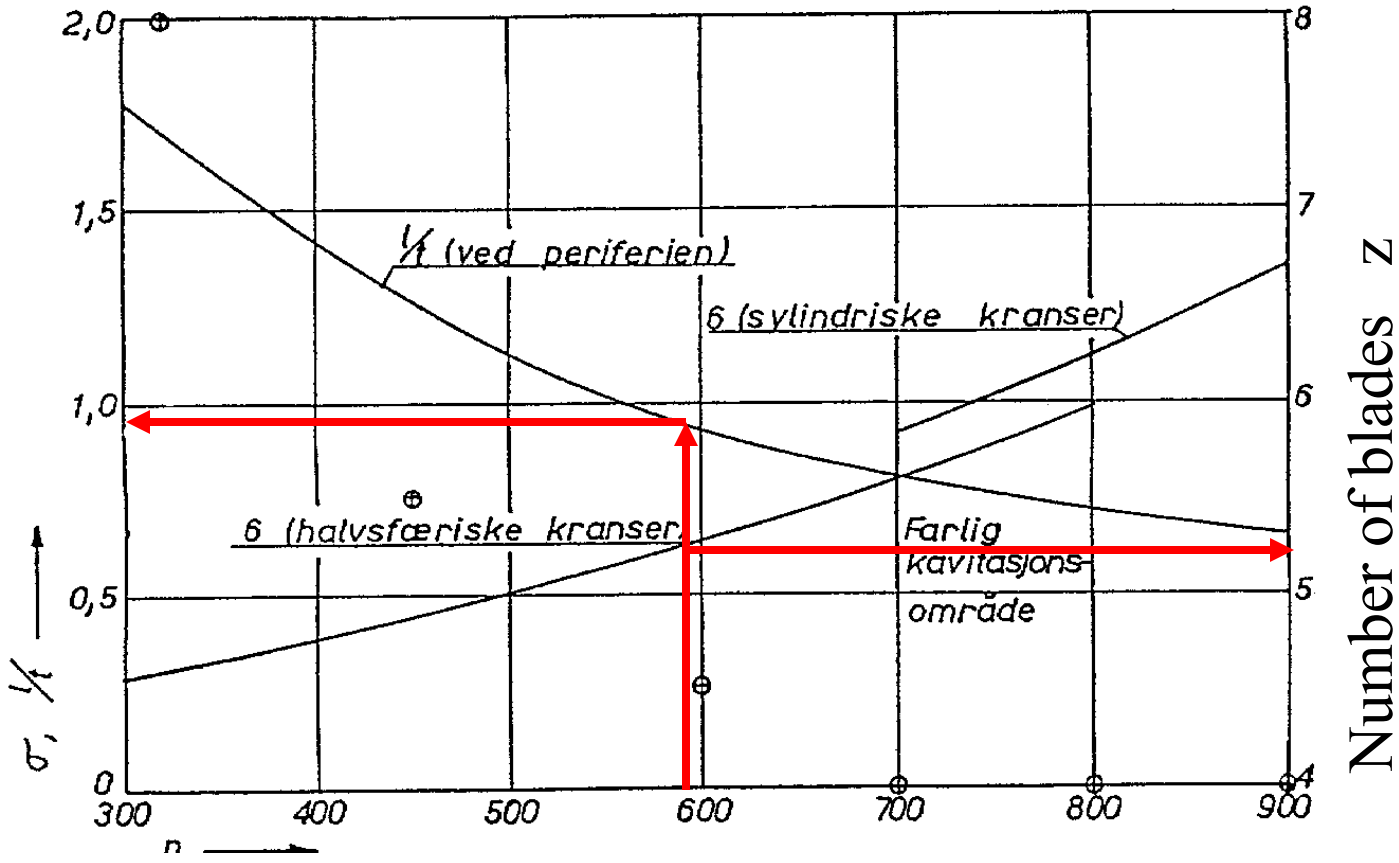
$$\frac{d}{D} = 0{,}45 \quad \Rightarrow \quad \boxed{d = D \cdot 0{,}45 = 1{,}9\ \text{m}}$$

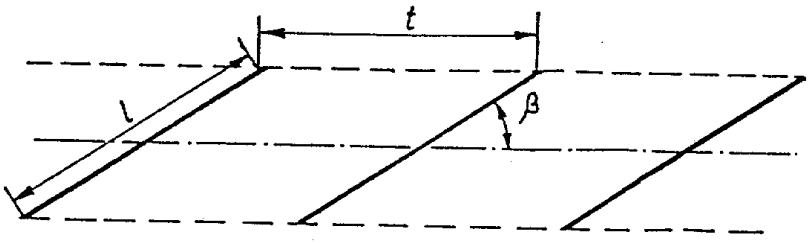
Height, B:



$$\frac{B_O}{D} = 0{,}41 \quad \Rightarrow \quad \boxed{B_O = D \cdot 0{,}41 = 1{,}76\ \text{m}}$$

Number of vanes, z:





$$\frac{l}{t} = 0{,}95$$

$$z = 5$$